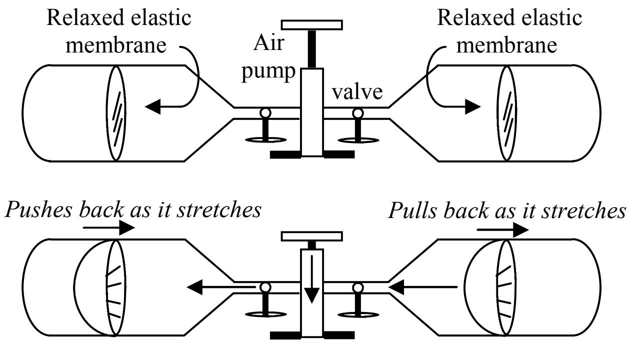
Due Fri., Feb 13

2011-12 PreAP Electrostatics 13

Imagine an air pump connected to two air tanks, one on each side. Each air tank has an elastic membrane (like a balloon) inside of it. The entire system is sealed. The air pump can supply a maximum of 2 atmospheres of pressure and can only push to the left.



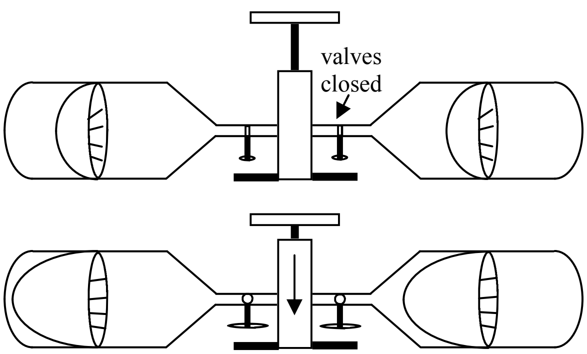
1. When the pump is pushed down air is pushed from the ______ side to the ______ side.
2. Which side loses air?
3. At first, how much back pressure is there in the left tank?
4. What is the total change of air for the entire system?
5. The pump will continue to pump until the back pressure (pushing back) equals:

1. right to left

3. zero—pump hasn't pushed yet.

4. Zero—it is moved to the left, but same air.
5. 2 atm, same as max pressure of pump.

The valves are then closed so that no air moves in or out of either tank and a larger pump is placed in the system. The new pump can supply 6 atm of pressure.



6. When the valves are opened, why will the new pump be able to push more air into the left tank?
7. Did the capacity of the tanks increase when the strength of the pump increased?
8. How has the total amount of air moved between the tanks changed?
9. When will the air flow stop?

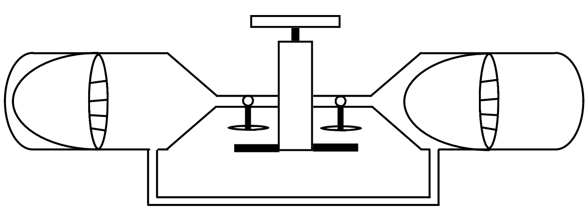
6. new pump can push harder (6 atm)

7. NO—tanks are the same size.

8. More pressure = more air moved.

9. when it equals 6 atm (the pump's maximum pressure)

We could keep replacing the pump with stronger and stronger pumps and get more and more air moved, but the size of the tank keeps constant. Eventually we could rupture the tank with too much pressure.



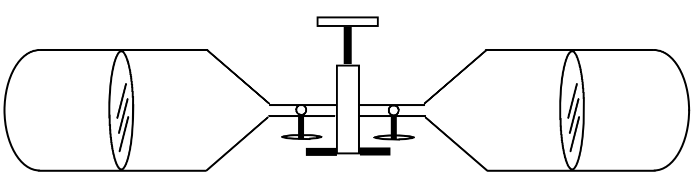
While the tanks are pressurized, we have potential energy. We could connect to something like a windmill and use this the mechanical energy. But for now we will discharge the tanks back to neutral by connecting them to each other with a pipe.

10. Describe what happens and draw the direction of the air flow.

11. How does the flow of air coming from the tank differ from that of the pump (especially over time)?

11. pump's air is constant. Tank's air will decrease over time.

Instead of a bigger pump, though, there is another way to store more air: bigger tanks, with more air capacity. We have changed the physical characteristics of the tanks. Also, let's put back our original, smaller pump.



12. What will be the final back pressure of the tanks when it stops filling?
13. Will the total amount of stored air in the left tank be greater, less than, or equal than with the smaller tanks?

12. 2 atm

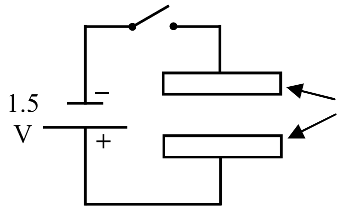
13. greater, bigger tanks.

So, with greater capacity (larger tanks) you can store more air with the same pump pressure.

14. If the left tank increased by 3 liters of air, what is the change of air in the right tank?
15. What is the net change of air for the entire system?
16. If we again switch to the larger pump, will the capacity of the tanks increase?
17. If we switched to the larger pump, will the amount of air moved to the left tank increase?

14. −3 liter
15. 3−3 = 0 total
16. No, the pump doesn't change the tank
17. Yes, of course.

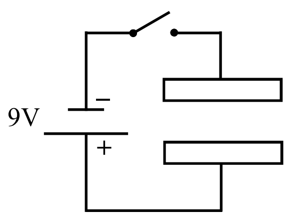
If you haven't already realized it, the pump represents the battery and the tanks represent a capacitor. Electrical capacitors work very similarly in many aspects. Obviously, it is not air that is moving.



18. What does move in an electrical circuit?

Instead of tanks, the simplest capacitors have two metal plates.

19. What is the charge of each plate before the switch is closed?
20. Do electrons flow out of the positive or out of the negative side of the battery?
21. So, label with −'s the side of the capacitor that becomes negative.
22. Just as in the tanks, where do these electrons come from?
23. Objects that lose electrons become:
24. Label the other plate with +'s.
25. Just like with the tanks, when will the capacitor stop charging?
26. What will be the final voltage across the capacitor plates?
27. Let's pretend that the charge on the negative plate (Q_{neg}) = −3C. What is the charge on the positive plate?
28. What is the net charge of the capacitor?



Then the battery is replaced with a larger battery.

29. Does the capacitance of the capacitor increase?
30. What will happen to the amount of charge (Q) on the plates?
31. When will the capacitor stop charging?
32. What will be the net charge of the capacitor?
33. How would you discharge the capacitor?
34. What happens when the capacitor is discharged?
35. Thinking back to the tanks, how could you increase the capacitance of the capacitor?

18. Electrons, silly!
19. neutral
20. Out of neg side.
21. Put −'s on the top plate
22. The other plate
23. Positive
24. +'s on lower plate
25. When = V battery
26. 1.5 V
27. +3C
28. 0 C (neutral)
29. No, plates are still the same size
30. Will increase again
31. When it reaches 9V
32. Neutral, always.
33. Connect two plates with a wire.
34. Electrons flow back to the + plate.
35. Make the plates larger